Alkali-Silica Reaction in Concrete

G.Geng, R. Dähn, E. Wieland
Paul Scherrer Institute, Villigen, Switzerland
M. Bagheri, S. Barbotin, E. Gallyamov, R. Rezakhani, K. Scrivener, J.-F. Molinari
Ecole polytechnique Fédéral, Lausanne, Switzerland
M. Shakoorioskooie, Z. Shi, B. Lothenbach, M. Griffa, A. Leemann, P. Lura
Empa, Materials and Technology, Dübendorf, Switzerland

Introduction

Alkali-silica reaction (ASR) causes cracking (Fig. 1) and with it substantial damages in concrete structures worldwide. In Switzerland, several hundreds of structures, including bridges and dams, are affected (Fig. 2), causing substantial costs due to repair or replacement. Although ASR is one of the major focal points of concrete research since the first cases were reported in the 1940's, our knowledge is still not sufficient to understand various aspects of the reaction. An improved understanding is needed for mitigation and management of affected structures.

In a Sinergia-project (SNF CRSII5_171018) a multidisciplinary and multiscale approach is applied to link chemical and mechanical aspects of ASR. The participating institutes bring together the fields of chemistry and thermodynamic modelling, structural analysis of reaction products, 2-D and 3D X-ray characterization complemented by mechanical modelling.

The project started in May 2017. The four PhD and two postdoc students are making excellent progress and are preparing the first conference and journal atricles.

Fig. 1: *ASR-typical crack pattern with dark linings of extruding reaction products.*

Fig. 2: The *Ganter bridge with a span of 678 m is affected by ASR.*

Approach

subproject 1: aggregate dissolution in different pore solutions, kinetics
subproject 2: composition/structure of 1st and 2nd stage ASR products
subproject 3: atomic structure of natural and synthetic ASR products
subproject 4: synthetic ASR products. Solubility and volume changes
subproject 5: ASR damage of aggregates, its evolution and its consequences
subproject 6: multi-scale computational modeling of ASR damage evolution

ASR products atomic structure ⇒ chemical reactivity and water adsorption ⇒ atomic-scale expansion

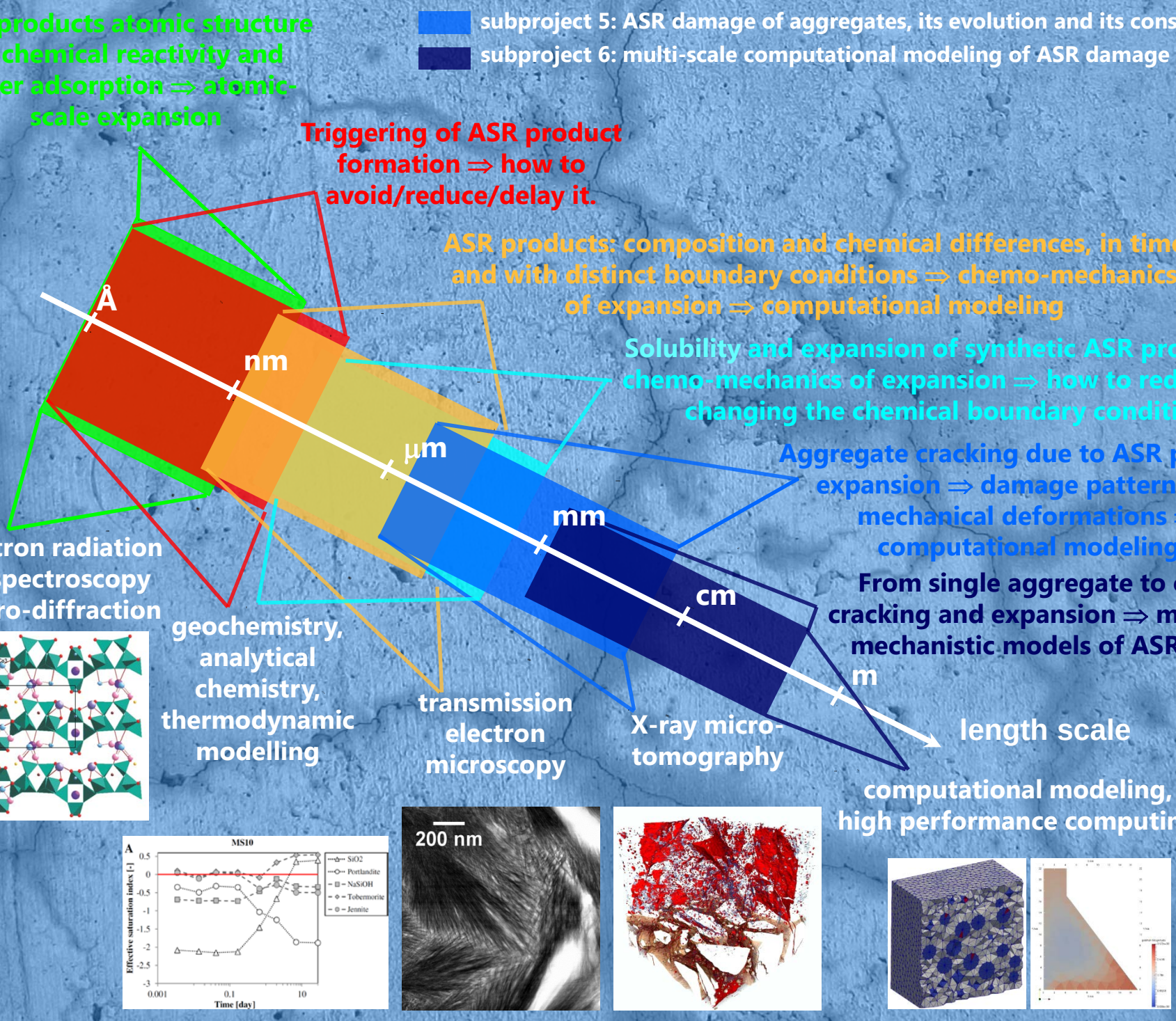
Triggering of ASR product formation ⇒ how to avoid/reduce/delay it.

ASR products: composition and chemical differences, in time and with distinct boundary conditions ⇒ chemo-mechanics of expansion ⇒ computational modeling

Solubility and expansion of synthetic ASR products ⇒ chemo-mechanics of expansion ⇒ how to reduce it by changing the chemical boundary conditions

Aggregate cracking due to ASR products expansion ⇒ damage patterns and mechanical deformations ⇒ computational modeling

From single aggregate to concrete cracking and expansion ⇒ macroscopic mechanistic models of ASR damage



synchrotron radiation micro-spectroscopy and micro-diffraction

geochemistry, analytical chemistry, thermodynamic modelling

transmission electron microscopy

X-ray micro-tomography

computational modeling, high performance computing

Contact: A. Leemann (andreas.leemann@empa.ch)